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(71) Applicant *(for all designated States except US)*: **GRAMPIAN UNIVERSITY HOSPITALS NHS TRUST** [GB/GB]; Foresterhill House, Ashgrove Road West, Aberdeen AB25 2ZB (GB).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **JOHNSTONE, Alan, John** [GB/GB]; The Elms, 7 North Deeside Road, Bieldside, Aberdeen AB15 9AD (GB).

(74) Agent: **MURGITROYD & COMPANY**; 165-169 Scotland Street, Glasgow G5 8PL (GB).

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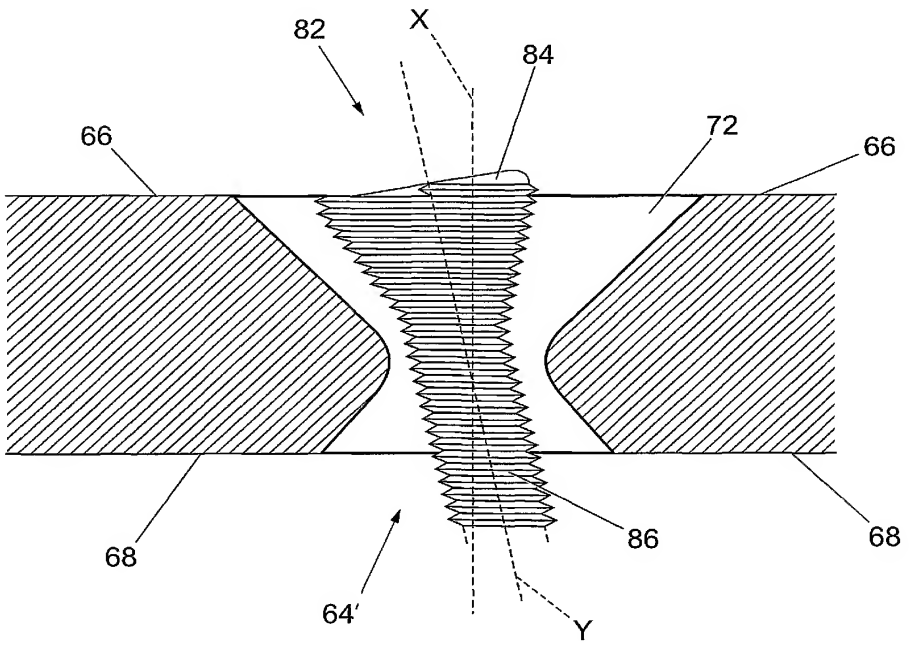

(57) Abstract: A bone fixture apparatus such as plate or an intramedullary nail is disclosed, having a plug or other form of insert that engages screws passing through the nail or plate etc. The provision of the pliable insert allows the screw to be driven through the plate etc at a number of different angles. The application also concerns a pliable insert suitable for use with the plate or nail.

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"Apparatus"

This invention relates to apparatus for use in supporting a fractured bone.

It is known to support fractures in bones by rigid bone fixture implants, common examples of which are bone plates (commonly known as interlocking plates) and intra-medullary (IM) nails.

IM nails are inserted into the medullary canal of the long bone, and are held in place by screws or other bone fasteners such as bolts or pins that are driven laterally through the bone, typically at each end of the nail. The screws etc also pass through pre-drilled holes in the nail, thereby reducing or preventing movement of the nail while the fracture is healing. Holes must be bored through the bone in order to insert the screws, and these must be aligned with the pre-drilled holes in the ends of the nail.

In order to drill the holes accurately through the bone, a jig is commonly employed. The jig is attached to the protruding end of the nail after insertion of the nail into the medullary canal, and typically extends parallel to the nail. The jig has pre-drilled holes that align with the holes in the nail when the jig and the nail are properly attached.

Interlocking bone plates are normally attached to the exterior surface of bones using similar bone fasteners such as bolts or screws. Like the IM nail, the plate is arranged to span fractures and the bone fasteners penetrate solid bone on opposing sides of the fracture(s).

According to the present invention there is provided a bone fixture apparatus having a pliable material for engaging a fixing device.

The bone fixture apparatus can be attached to the outer or the inner surface of the bone. Typically, the bone fixture apparatus comprises an intra-medullary nail. Alternatively, the bone fixture apparatus comprises a bone plate (internal or external). Alternatively, the bone fixture apparatus comprises a fracture brace.

Typically, the pliable material is capable of plastic and/or elastic deformation, and can typically be a coating or insert. The pliable material is typically softer that the material of

the bone fixture apparatus, and has a lower Young's modulus. The pliable material is preferably soft enough to drill, mill or cut peroperatively, typically under the influence of materials that are harder than the pliable material. Typically such harder materials are used for the fixing device which is driven into the pliable material.

Optionally, the pliable material is a metal or a polymer. In certain embodiments the pliable material can be biodegradable. Biodegradable variants are useful as the plate or nail typically needs to be firmly attached to the bone without allowing any movement only in the initial phase of the fracture, so that it can take the loading normally applied to the fractured area of bone arising from everyday use. After the fracture has healed, the implant is redundant and no longer needs to bear any load. In some cases, the implant can be left in place permanently, but in other cases, the implant can be removed from the bone, and biodegradable inserts of the pliable material can assist in such removal, as by the time the bone has healed, the pliable material will have been eroded, and the fixings can be more easily removed.

Biodegradable versions of the insert also lend themselves very well to use with bone plates having dynamization slots, as the screw can be driven through the dynamization slot filled with the pliable insert, and the degradation of the insert over the succeeding weeks or months will then free

the screw to move axially in the slot once the initial healing has progressed to a suitable phase where this movement is desirable, but retaining a secure fixing of the screw, plate and bone when this is necessary in the initial phase before healing of the bone fracture.

The pliable material can be a non-metallic material such as plastics material or an expanded carbon complex. A further possibility is that the pliable material is a naturally occurring (and preferably bioabsorbable) material such as a collagen or polypeptide construct.

The apparatus may have a hole to receive the fixing device, and the pliable material may preferably be located at or in the hole. Preferably, the pliable material is positioned e.g. bonded on a surface (typically the internal surfaces of an aperture or bore) of at least a part of the bone fixture apparatus. Preferably, some pliable material is disposed in the region(s) of the bone fixture apparatus around or within the hole(s). In some embodiments in the form of hollow nails etc, the pliable material can be inserted into a central canal of the nail.

In some embodiments, the pliable material is settable so that it changes phase (e.g. from paste, gel or liquid to a solid) on the application of pressure or heat, when exposed to a chemical

catalyst, or after an interval of time. Optionally, the settable material is a glue or a paste.

The pliable material is optionally self-expanding. Optionally, the pliable material changes phase, e.g. from liquid to solid when it expands.

Optionally, the bone fixture apparatus has predrilled holes to receive fixings. The holes can be on different planes, and can be lateral holes or in other planes. The holes can be filled or lined with pliable material. Optionally, screws or other bone fixings are inserted into the pliable material to form holes through the pliable material. In such cases the bone fixture apparatus can have a window through which the pliable material is exposed to the fixing, and through which the screw etc can be inserted. In certain cases the pliable material can have a pilot hole pre-drilled therein to receive the bone fixing.

Preferably, the fixing device is a screw or a bolt. Threaded fixings are preferred, but non-threaded fixings such as pins etc can be used. Preferably, the fixing device is longer than the diameter of the apparatus.

In some nails formed as a rolled tube, each hole has a circumferentially opposite hole. Each hole (or pair of opposite holes) can typically receive the fixing device. Potentially, the pair of opposite holes could form the ends of a generally cylindrical

passage through a solid nail. The entire passage could be filled with pliable material, or alternatively the walls of the passage could be at least partially lined with pliable material. In some embodiments the pliable material can comprise at least one ring (preferably two rings) of e.g. plastics material such as Nylon(TM) on the inner diameter of (or within) at least one of the holes (preferably each end of each hole has a respective ring).

Optionally, the pliable material extends down the full length of cannulated nails, although it is only necessary for the pliable material to be located where the fixing devices engage the bone fixture apparatus; thus the pliable material and/or the holes to engage the bone fixings could be anywhere on the apparatus.

Optionally, the holes have parallel sides, but in certain embodiments, the sides of the holes are tapered. Bi-directionally tapered embodiments, where the sides of the holes taper inwardly from both the upper and lower surfaces of the bone fixing apparatus to an apex, can be advantageous, as the narrower width of the hole at the apex can serve to hold the pliable material in position, without the need for an adhesive. The apex of the hole is typically located just below the centre point of the hole axis. The embodiments having bi-directional tapering are typically used with a solid insert of

pliable material which fills, or nearly fills the hole.

Optionally, the pliable material is in the form of an insert which has a compressible portion. This kind of insert is especially useful for use with holes having a narrow portion. The compressible portion can be compressed to fit through the narrow portion of the hole. The compressible portion may have legs divided by elongate slits. The slits are typically wedge-shaped, and allow for the legs to be pushed together to reduce the diameter of the compressible portion. For example, before compression, the legs may form part of a frusto-conical portion of the insert; thus the legs have a partially radial extent. On compression, the legs can be squeezed into a cylindrical shape to fit through the narrow portion of the hole. It is useful if the compressible portion is formed from a resilient material, so that when the legs have passed through the narrow portion of the hole, they extend radially outwards again to hold the insert in the hole.

Other embodiments of bone fixing apparatus have tapered frusto-conical holes. These may be used with inserts which fill the holes, or alternatively, the hole walls may be lined with the pliable material.

The holes in the bone fixing apparatus may be screw-threaded and the pliable material may be in the form

of an insert having corresponding threads; alternatively, threads may be formed in the insert on screwing the insert into the threaded holes.

Optionally, the nail can be hollow and the entire cross-section of the nail is filled with the pliable material, at least in the areas where the screws will engage the nail, e.g. at the ends. Alternatively, the bone fixture apparatus can be solid and the pliable material can comprise a hollow sleeve or ring(s), or a solid plug inside a passage through the bone fixture apparatus adapted to receive the fixing screws. Another possibility is that the pliable material lines the inside surface of a hollow bone fixture apparatus.

According to a further aspect of the present invention, there is provided a method of supporting a fractured bone, the method comprising the steps of: attaching a bone fixture apparatus to the bone and engaging at least one fixing device with the bone, wherein the bone fixture apparatus is provided with a pliable material and the fixing device is engaged with the pliable material.

The bone fixture apparatus may comprise an intra-medullary nail, and the method optionally includes the step of inserting the intra-medullary nail into the medullary cavity of the bone. Alternatively, the bone fixture apparatus may comprise a bone plate.

Preferably, the apparatus spans one or more fractures in the bone, and the screws are driven into the bone fixture apparatus on opposing sides of the fracture(s).

The pliable material is typically attached to a part of the bone fixture apparatus.

The fixing device may optionally be inserted through at least one hole in the bone fixture apparatus; the hole is typically at least lined and optionally filled with pliable material. The pliable material may be inserted into the hole either before or after the bone fixture apparatus is attached to the bone.

A simple option is to fill the holes in the bone fixture apparatus with pliable material. A simple ring of plastic material around the inside of each hole would be sufficient, and in such cases the inner diameter of the ring is preferably less than the diameter of the shank of the screw. Another possibility is to insert one or more sleeves or cylinders of pliable material to span the gap(s) between holes in opposite sides of a hollow bone fixture apparatus and is supported by the holes.

Typically, the pliable material acts to minimize movement of the screw with respect to the bone fixture apparatus.

Typically, inserting a screw displaces some of the pliable material, which expands against a surface of

the bone fixture apparatus. This expansion force helps to hold the screw stationary with respect to the bone fixture apparatus. In such examples, the pliable material is typically contained within a containment area in the bone fixture apparatus, so that when the pliable material expands it pushes against the walls of the containment area and increases the grip between the bone fixture apparatus and the screw. In certain embodiments the material can be self-expanding, and this can increase the grip of the screw on the bone fixture apparatus. In other embodiments of the invention, the screw can cut threads in the pliable material and this can help to hold the screw steady relative to the bone fixture apparatus. Preferably the pliable material is contained or received within the hole that also accommodates the fixing device, and the act of driving the fixing device through the pliable material in the hole expands or deforms the pliable material within the hole and holds the fixing therein.

According to a further aspect of the present invention, there is provided the use of a pliable material in co-operation with a bone fixture apparatus in a method of supporting a bone fracture.

According to a further aspect of the present invention, there is provided a pliable insert for engaging a fixing device for a bone fixture apparatus.

According to a further aspect of the present invention, there is provided a bone fixing apparatus having at least one hole, wherein the hole is provided with a tapered inner surface.

An embodiment of the invention will now be described by way of example only and with reference to the following drawings, in which:-

Fig 1 shows a cross-sectional view of an intra-medullary nail inside the medullary canal of a broken bone;

Fig 2 shows a side view of an intra-medullary nail attached to a jig;

Fig 3 shows a cross-sectional view of an intra-medullary nail filled with a pliable material;

Fig 4 shows a cross-sectional view of the apparatus of Fig 3 with a screw extending through the nail;

Fig 5 shows a cross-sectional view of an intra-medullary nail on the interior of which is an annulus of pliable material;

Fig 6 shows the cross-sectional view of the apparatus of Fig 5 with a screw extending through the nail;

Fig 7 shows a cross-sectional view through a solid nail in accordance with another embodiment;

Fig 8 shows a cross-sectional view through a solid nail in accordance with a further embodiment;

Fig 9 shows a cross-sectional view through a tubular nail in accordance with another embodiment;

Fig 10 shows a cross-sectional view through a tubular nail in accordance with a further embodiment;

Fig 11 is a front view of a bone plate according to the invention;

Fig 12 is an enlarged view of one of the holes in the bone plate of Fig 11;

Fig 13 is a cross-sectional view taken along the line A-B of Fig 12;

Fig 14 is a cross-sectional view of the bone plate of Fig 11 having a pliable insert;

Fig 15 is a cross-sectional view of the bone plate of Fig 11 having an alternative embodiment of insert;

Fig 16 shows a cross-sectional view of the Fig 14 bone plate and pliable insert, having a screw driven through the insert; and

Figs 17 and 18 show cross-sectional views of a further embodiment of bone plate and insert.

Referring now to the drawings, Fig 1 shows a bone fixture apparatus in the form of an intra-medullary nail 10, which is inserted inside the medullary canal 12 of a broken bone 14. The broken bone 14 consists of two bone portions 16A and 16B. The intra-medullary nail 10 extends substantially the whole length of the medullary canal 12.

Fig 2 shows an intra-medullary nail 10 attached to a jig 20 at one end. Both the nail 10 and the jig have holes 18, 28 at each of their ends. Each hole 18 in the nail 10 is aligned with a respective hole 28 in the jig. A screw 26 is shown inserted through a hole 18 in the nail 10, and a hole 28 in the jig 20.

One embodiment of the invention is illustrated in Figs 3 and 4.

Fig 3 shows a hollow intra-medullary nail 10 of the rolled tube type, which has lateral holes 18 aligned at the same axial position on each side at the end of the nail 10. The nail 10 is entirely filled with a pliable material comprising a cylindrical insert 30 of polyethylene, which is inserted into the end of the nail 10.

In use, the nail 10 is inserted into the medullary canal of the bone portions 16A, 16B to be aligned. The cylinder 30 of pliable material is inserted into the nail 10 either before or after the nail 10 is inserted into the medullary canal. The nail 10 is then optionally attached at one end to a jig 20. At least one screw 26 is driven into the bone on each side of the break, at positions aligned with holes in the jig 20 and holes 18 the nail 10. The screws 26 pass through the holes 28 in the jig 20 and the holes 18 in the nail 10, and engage the cylinder 30 of pliable material. The screw threads of screws 26 cut into the pliable material 30 as the screws are

driven into it, thereby ensuring a firm grip of the screw by the cylinder 30. The pliable material of the cylinder 30 is also displaced radially outwards and expands against the inside surface of the nail 10, thereby pressing the cylinder 30 against the nail 10. The increased grip between the screw 26 and the cylinder 30 and between the cylinder 30 and the nail 10 helps to keep the screws 26 stationary with respect to the nail 10, thereby preventing or restraining movement of the nail in the bone 16 which can disrupt the healing process.

It should be understood that the use of the jig is not essential for the working of this invention; it is merely a useful tool to help to locate the holes for the screws in alignment with the holes in the nail 10.

Fig 4 shows the apparatus of Fig 3, with a screw 26 inserted through the holes 18 in the nail 10, and through the cylinder 30. The pliable material of the cylinder 30 has been squeezed outwards against the inner surface of the nail 10 by the movement of the screw 26, and exerts a force on the inside surface of the nail 10 to keep the nail 10 in place.

An alternative embodiment of the invention is described in Figs 5 and 6. This embodiment is similar to that of Figs 3 and 4, except that the pliable material is in the form of a liner or sleeve 32 that lines the inside surface of the nail 10 as

shown in Fig 5, instead of filling the entire cross-section.

In use, the nail 10 is inserted into the medullary canal as before. A hollow sleeve 32 of pliable material is inserted into the nail 10 either before or after the nail 10 is placed into the canal. The nail 10 is then attached at one end to a jig 20. At least one screw 26 is driven into the bone on each side of the break at positions aligned with holes 28 in the jig 20 and holes 18 in the nail 10. Screws 26 are inserted through the hole 28 in the jig 20 and the hole 18 in the nail 10, and the screws 26 cut threads into the cylinder 32 of pliable material, which helps to keep the screw 26 and the intra-medullary nail 10 firmly connected with reduced scope for movement of the nail 10 in the bone during the healing process.

Fig 6 shows the embodiment of Fig 5 with a screw inserted through the nail 10 and through the cylinder 32 of pliable material.

The purpose of the pliable material is to hold the screw in position and any shape/amount/type of pliable material that achieves this function can be used. It is generally useful if a part of the pliable material forms, covers or surrounds a screw-receiving hole in the intra-medullary nail so that the screw self-taps into it, forming its own threads or hole in the pliable material. It is advantageous but not necessary for the pliable material to be

pressed against the nail, through either displacement by the screw, and/or the pliable material itself being self-expanding.

Figs 7 and 8 show how the invention can be applied to a solid nail 50, which has a lateral bore 58 to receive a screw. The bore 58 is lined with a sleeve 52 in the fig 7 embodiment that is formed from pliable material (in this case the pliable material is a polyamide). The sleeve 52 is deformed by the screw threads as the screw penetrates the bore, and this enhances the grip between the nail and the screw. The sleeve 52 can be replaced by one or more annular rings 54 that can usefully be positioned at opposite ends of the bore 58 as shown in the Fig 8 embodiment.

The annular rings 54 or the sleeve 52 can be used in a tubular nail 10 as shown in Fig 9 and Fig 10. It is not important which particular pliable material is used; suitable materials include metals, polymers (absorbable/non-absorbable), non-metallic materials (e.g. carbon complexes) and naturally occurring materials (e.g. collagen constructs).

It could be advantageous for the patient if only small quantities of pliable material are used, so as to keep the amount of foreign agents in his body to a minimum. Typically pliable materials that are biodegradable are preferred.

A further alternative embodiment of the invention is shown in Figs 11 to 14. Fig 11 shows a bone plate 60 which has a series of oval holes 62 and circular holes 64 along its length; each hole extends through the plate from an upper surface 66 of the plate to a lower surface 68. One of the circular holes 64' is shown in more detail in Figs 12 and 13.

As best seen in Fig 13, the hole 64' has walls 65 which are tapered so that they are inclined relative to each other and to the upper and lower surfaces 66, 68 of the bone plate. The hole 64' also has a central axis X.

The wall 65 of the hole 64' inclines radially inwardly towards the hole axis X from the top surface 66 to an apex 70, from where the wall 65 inclines radially outwards to the lower surface 68. The apex 70 is located slightly below the midpoint of the hole 64'. The cross-section of the hole 64' thus generally resembles an hourglass.

Referring now to Fig 14, a pliable insert 72 also having the form of an hourglass is shown inserted into the hole 64'. The pliable insert 72 is formed so that it fits inside the hole in a clearance fit. Ideally, once inserted there should be essentially no gap between the insert 72 and the wall 65 of the bone plate 60.

The pliable insert 72 can typically be squeezed into the hole 64'. For example, the material of the

pliable insert 72 could be chosen such that a slight heating of the pliable insert 72 would make the insert 72 compressible to fit in the hole 64'. Other embodiments can be envisaged where the pliable insert 72 is formed in the hole 64' by melting the pliable material and allowing it to set within the hole.

Once inserted, the insert 72 is retained in the hole 64' by the hourglass-shape of the walls 65. The insert 72 would typically be inserted into the hole 64' before surgery, but in certain circumstances the insert 72 can be inserted peroperatively.

The interior surfaces of the other holes 62, 64 in the bone plate 60 have a similar shape.

Fig 15 shows the hole 64' of the bone plate 60 having an alternative embodiment of pliable insert 76, typically made from a resilient material such as a resilient plastics material or a rubber. The lower end 78 (defined with reference to the bone plate) of the insert 76 has wedge-shaped slits 80 cut between adjacent legs. The slits 80 are aligned parallel to the axis X, with the tip of each cut-out wedge at the upper end of each slit 80, giving a pleated effect. The legs of the insert 76 do not extend all of the way to the lower surface 68 of the plate 60 in this embodiment. The upper end 77 of the insert 76 mirrors the shape of the upper parts of the walls 65.

The insert 76 is engaged in the hole by squeezing the legs at the lower end 78 of the insert 76 so that the slits 80 are compressed together, the legs are parallel to one another, and the lower end 78 of the insert 76 is squeezed into a generally cylindrical arrangement that can pass the apex 70 of the walls 65. Thus, the insert 76 can be squeezed into the hole 64' and once in position, the resilience of the pliable insert 76 will cause the slits 80 to assume their original wedge-like shapes, splaying the legs outwards, and the lower end of the insert 76 will be trapped below the apex 70, thus retaining the insert 76 in the hole 64', as shown in Fig 15.

This embodiment provides the advantage that the insert 76 can be inserted into the hole 64' without any external heating or special application of extra force, so the insert 76 can easily be inserted into any suitable hole at any time before or during the operation with an easy press-fit. Driving a fixing device such as a screw through the insert 76 will keep the legs splayed and securely anchor the insert 76 within the hole 64'.

Fig 16 shows the bone plate 60 and insert 72 of Fig 14, with a screw 82 screwed into the insert 72. The screw 82 has a head 84 and a shaft 86, both of which are threaded. The screw 82 is inserted far enough into the insert 72 such that the head 84 is threaded into the insert 72 in addition to the shaft 86. The threads of the screw 82 cut into the bone (not

shown) and the screw 82 acts as a fixing device to attach the bone plate 60 to the bone.

The axis of the screw 82 is shown by the line Y in Fig 16; it is not co-axial with the axis X of the hole 64' but is inclined relative thereto. The invention provides the significant advantage over conventional bone fixing devices that it allows the selection of the angle of insertion of the screw 82, without the surgeon being forced to change the attitude or orientation of the hole or the bone plate 60. Examples of several possible screw orientations are shown as dotted lines S, T, U, V in Figs 14 and 15. The screw position/angle is typically chosen prior to the insertion of the screw 82. The angle of screw insertion would typically be influenced by the diameter of the leading thread of screw, the core diameter of the screw, and the shape and diameter of the screw head.

The insert 76 of the Fig 15 embodiment can receive a screw in just the same way as shown in Fig 16 for the insert 72.

The inserts 72, 76 could either be formed with one or more predrilled holes for insertion of screws, or alternatively, the inserts 72, 76 could be solid and the screw holes could be drilled according to the surgeon's requirements or judgement during the operation. An advantage of pre-drilled holes is that this eliminates the possibility that the surgeon might drill through the insert and into the

bone plate. On the other hand, if a hole is drilled in a solid insert during the operation, the surgeon has complete freedom of choice of hole angle.

The embodiments described in Figs 14 to 16 are adapted for circular holes and have axial symmetry, so that the inserts 72, 76 can be rotated in their respective holes. Rotation of the insert 72, 76 sweeps the angle of the hole around in an arc, allowing the surgeon even more freedom of choice to insert the screw 82 at the required angle, or in the required direction.

Fig 17 shows a yet further alternative embodiment, wherein a bone plate 90 has an upper surface 92 and a lower surface 94. The bone plate 90 has holes 96 (only one shown) having tapered walls. The hole 96 is frusto-conical, the narrower end being at the lower surface 94 and the wider end being at the upper surface 92. Thus, the walls of the hole 96 are inclined radially inwards from the upper surface 92 to the lower surface 94. Unlike the embodiments of Figs 11 to 16, there is no apex in the surface of the walls, the inclination being typically continuous between the upper and lower surfaces 92, 94, although an annular stop could be formed at the lower surface 94 if desired (not shown).

The hole 96 has a pliable insert 98 inserted therein. The insert 98 is also in the form of a trapezium, being dimensioned to fit the shape of the hole 96, so that the insert 98 fits in and fills the

hole 96 as shown in Fig 17. The angle of inclination of the sides is exaggerated in figure 17, and in practice any significant inclination of the walls is useful, as it permits the insert to enter and leave the hole only through the wider aperture of the top surface 92.

In certain simple embodiments of this version, the sidewalls (i.e. not the upper and lower surfaces) of both of the insert 98 (typically) and the hole 96 can be plain, but in the more advanced embodiment chown the sidewall of at least the hole 96 is screw threaded in order to grip the insert 98 more securely. The outer wall of the insert can also be threaded as shown in this embodiment, but in other versions, it is sufficient for the thread to be cut into the insert 98 by the thread on the hole 96 during insertion of the insert 98 into the hole 96. In this example, the coupled threads are designated 100 in the drawing. Therefore, this embodiment provides a pliable insert that can be screwed into a bone plate by engaging the threads of the plate aperture and the insert. The insert 98 can be screwed into holes in conventional bone plates where required in order to fix the insert more securely to the plate. Thus, when the screw or other bone fixing device is driven through the insert 98, the consequent deformation of the insert 98 pushes the plastic of the insert even more firmly into the threads on the inner surface of the hole 96, thereby reducing the possibility of the insert allowing any

play of the plate and fixing after the two are finally connected.

As with previous embodiments, the screws or other fixings can be driven through the solid plug of the insert 98 or alternatively the insert 98 can have pre-drilled holes to guide insertion of the fixings. Naturally, with pre-drilled holes in the insert 98, the insert 98 can be rotated to select a suitable path for the fixing into the bone. This feature can be especially useful if part of the bone is comminuted, the bone portions in these parts being very tiny, and where especially accurate selection of the angle of insertion of the screws is required. In some embodiments, some of the holes in the bone plate could be used with screws directly, and the holes relating to the comminuted parts of the fracture could be filled with an insert according to the invention.

Fig 18 shows the Fig 17 insert 98 with a screw 82 driven therethrough.

The invention allows the use of smaller screws, as in this invention, the size of the screw is not defined by the size of the hole in the bone plate; any size of screw smaller than the hole can be chosen. Again, this may be particularly useful for comminuted fractures.

If the conventional bone plate has holes with parallel walls, a correspondingly parallel-walled

insert could be provided. Therefore, this invention also provides embodiments which can be used in conjunction with conventional bone plates/ intramedullary nails, as and where required, to give the advantage of being able to select the angle of insertion of the hole and the required screw size.

It should be noted that the non-parallel sided designs of insert and bone fixture apparatus in the embodiments of Figs 11 to 17 could equally be applied to the intra-medullary nail embodiments; these do not necessarily relate only to bone plates.

It should also be noted that in the embodiments of Fig 17 and 18 it is not necessary for the insert 98 to be threaded, and the thread can be cut into the insert 98 by the act of screwing a blank insert 98 into the hole.

Modifications and improvements can be incorporated without departing from the scope of the invention. For example, the bone fixture apparatus may be a bone plate, a fracture brace or any other kind of bone fixture apparatus; the invention does not necessarily relate to intra-medullary nails.

Other types of pliable material may be used beyond the types specifically mentioned above.

The bone fixture apparatus does not necessarily include holes. For example, the pliable material could be bonded to the bone fixture apparatus and a

fixing device could be engaged with the pliable material alone.

Claims

1. A bone fixture apparatus having a pliable material for engaging a fixing device.

2. A bone fixture apparatus as claimed in claim 1, wherein the pliable material is deformable.

3. A bone fixture apparatus as claimed in claim 1 or claim 2, wherein the pliable material comprises an insert.

4. A bone fixture apparatus as claimed in any preceding claim, wherein the form of the pliable material is selected from the group consisting of a hollow sleeve, at least one ring, a plug, a coating and a liner.

5. A bone fixture apparatus as claimed in any preceding claim, wherein the pliable material is received in a threaded aperture in the apparatus.

6. A bone fixture apparatus as claimed in any preceding claim, wherein the pliable material is settable.

7. A bone fixture apparatus as claimed in any preceding claim, wherein the pliable material is expandable.

8. A bone fixture apparatus as claimed in claim 7, wherein the pliable material is self-expanding.

9. A bone fixture apparatus as claimed in any preceding claim, wherein the pliable material lines at least a part of the inside of the bone fixture apparatus.

10. A bone fixture apparatus as claimed in any preceding claim, wherein the pliable material is located within a passage of the bone fixture apparatus.

11. A bone fixture apparatus as claimed in claim 10, wherein the pliable material fills the transverse cross-sectional area of the passage.

12. A bone fixture apparatus as claimed in any preceding claim, wherein the bone fixture apparatus has at least one hole to receive a respective fixing device and wherein the pliable material is located in a region of the hole.

13. A bone fixture apparatus as claimed in claim 12, wherein the pliable material lines the inside of the hole.

14. A bone fixture apparatus as claimed in claim 12 or claim 13, having a cylindrical passage through the bone fixture apparatus terminating in a respective hole at each end of the passage.

15. A bone fixture apparatus as claimed in claim 14, wherein the pliable material is located at each

end of the passage, around the inside surface of the passage.

16. A bone fixture apparatus as claimed in claim 14 or claim 15, wherein the entire passage is filled with pliable material.

17. A bone fixture apparatus as claimed in claim 12 or claim 13, wherein the bone fixture apparatus is hollow and the pliable material is in the form of a sleeve or cylinder that spans the gap between holes in opposite sides of the bone fixture apparatus.

18. A bone fixture apparatus as claimed in any of claims 12 to 17, wherein the hole is tapered.

19. A bone fixture apparatus as claimed in any of claims 12 to 18, wherein the pliable material is in the form of an insert which fills the hole.

20. A bone fixture apparatus as claimed in claim 19 when dependent on claim 18, wherein the insert tapers to match the shape of the hole.

21. A bone fixture apparatus as claimed in claim 19 or claim 20, wherein the hole and the insert are frusto-conical.

22. A bone fixture apparatus as claimed in any of claims 19 to 21, wherein the insert has a compressible portion, which can be compressed to fit through a narrow section of the hole.

23. A bone fixture apparatus as claimed in claim 22, wherein the compressible portion has slits.

24. A bone fixture apparatus as claimed in claim 22 or claim 23, wherein the compressible portion is adapted to splay outwards to retain the insert in the hole after insertion.

25. A bone fixture apparatus as claimed in any of claims 19 to 24, wherein the insert is rotatable in the hole.

26. A bone fixture apparatus as claimed in any of claims 19 to 25, wherein the hole is provided with internal screw threads.

27. A bone fixture apparatus as claimed in claim 26, wherein the insert has external screw threads to engage the internal threads on the hole, such that the insert can be screwed into the hole.

28. A bone fixture apparatus as claimed in any of claims 19 to 27, wherein the insert has an aperture therethrough to receive a fixing device.

29. A bone fixture apparatus as claimed in any preceding claim, wherein the pliable material is contained within a containment area of the bone fixture apparatus.

30. A bone fixture apparatus as claimed in any preceding claim, wherein the pliable material is fixed to the bone fixture apparatus.

31. A bone fixture apparatus as claimed in any preceding claim, wherein the pliable material is selected from the group consisting of metals and polymers.

32. A bone fixture apparatus as claimed in any preceding claim, wherein the pliable material is selected from the group consisting of a plastics material, a carbon complex, polyethylene, nylon, and collagen and polypeptide constructs.

33. A bone fixture apparatus as claimed in any preceding claim, wherein the pliable material is biodegradable or bioabsorbable.

34. A bone fixture apparatus as claimed in any preceding claim, wherein the bone fixture apparatus comprises an intra-medullary nail.

35. A bone fixture apparatus as claimed in any of claims 1 to 33, wherein the bone fixture apparatus comprises a bone plate.

36. A method of supporting a fractured bone, the method comprising the steps of: attaching a bone fixture apparatus to the bone and engaging at least one fixing device with the bone, wherein the bone fixture apparatus is provided with a pliable

material and the fixing device is engaged with the pliable material.

37. A method as claimed in claim 36, wherein the fixing device is threaded, and wherein on insertion, the fixing device cuts threads in the pliable material to hold the fixing device relative to the pliable material.

38. A method as claimed in claim 36 or claim 37, wherein the insertion of the fixing device displaces some of the pliable material against the inside surface of the bone fixture apparatus.

39. A method as claimed in any of claims 36 to 38, wherein the pliable material is expandable upon application of pressure and the insertion of the fixing device causes the pliable material to expand.

40. A method as claimed in any of claims 36 to 39, wherein the pliable material is contained within a containment area in the bone fixture apparatus, and when the fixing device is inserted, the pliable material is displaced against the walls of the containment area.

41. A method as claimed in any of claims 36 to 40, wherein the fixing device is inserted through the bone and through at least one hole in the bone fixture apparatus.

42. A method as claimed in claim 41, wherein the pliable material lines the hole in the bone fixture apparatus.

43. A method as claimed in claim 41 or claim 42, wherein the pliable material is in the form of an insert which fills the hole in the bone fixture apparatus.

44. A method as claimed in claim 43, wherein the hole has internal threads, and the method includes the step of screwing the insert into the hole.

45. A method as claimed in claim 44, wherein the insert has external threads that engage with the threads on the hole.

46. A method as claimed in any of claims 43 to 45, wherein the insert is solid and an aperture is drilled in the insert during surgery.

47. A method as claimed in any of claims 43 to 45, wherein the insert has a predrilled aperture, which, in use, is inclined relative to the hole axis, and the method includes the step of rotating the insert to select the orientation of the aperture.

48. A method as claimed in any of claims 43 to 47, wherein the hole has an internal throat and the insert has a compressible portion, and the method includes the step of compressing the portion to fit

the insert at least partially through the throat of the hole.

49. A method as claimed in claim 48, wherein the compressible portion has legs which can be pushed together to compress the portion to fit the insert through the throat of the hole and which splay apart when in position in the hole to grip the hole.

50. The use of a pliable material in co-operation with a bone fixture apparatus in a method of supporting a bone fracture.

51. A pliable insert for engaging a fixing device for a bone fixture apparatus.

52. A pliable insert as claimed in claim 51, wherein the insert is deformable.

53. A pliable insert as claimed in claim 51 or claim 52, wherein the insert has external screw threads.

54. A pliable insert as claimed in any of claims 51 to 53, wherein the insert is settable.

55. A pliable insert as claimed in any of claims 51 to 54, wherein the insert is expandable.

56. A pliable insert as claimed in claim 55, wherein the insert is self-expanding.

57. A pliable insert as claimed in any of claims 50 to 56, wherein the insert tapers bi-directionally to form a waist.

58. A pliable insert as claimed in any of claims 51 to 57, wherein the insert has a compressible end.

59. A pliable insert as claimed in claim 58, wherein the compressible end has legs divided by slits, and wherein the legs can be pushed together to compress the end.

60. A pliable insert as claimed in claim 59, wherein the legs of the insert are adapted to splay outwards on the engagement of a fixing device with the insert.

61. A bone fixture apparatus as claimed in any of claims 51 to 60, wherein the insert has an aperture therethrough to receive a fixing device.

62. A pliable insert as claimed in any of claims 51 to 61, wherein the insert comprises a material selected from the group consisting of metals and polymers.

63. A pliable insert as claimed in any of claims 51 to 62, wherein the insert comprises a material selected from the group consisting of a plastics material, a carbon complex, polyethylene, nylon, and collagen and polypeptide constructs.

64. A pliable insert as claimed in any of claims 51 to 63, wherein the insert is biodegradable.

65. A bone fixing apparatus having at least one hole, wherein the hole is provided with a tapered inner surface.

66. A bone fixing apparatus as claimed in claim 65, wherein the hole is bi-directionally tapered to form a throat.

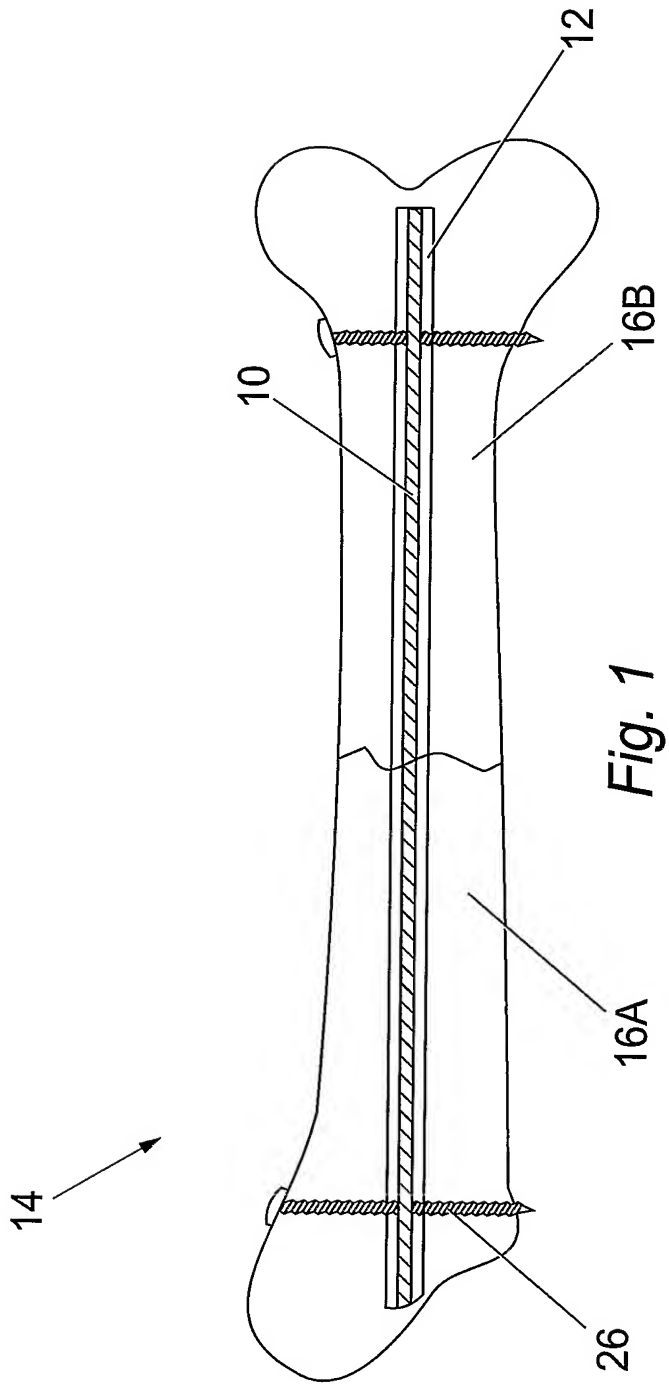

Fig. 1

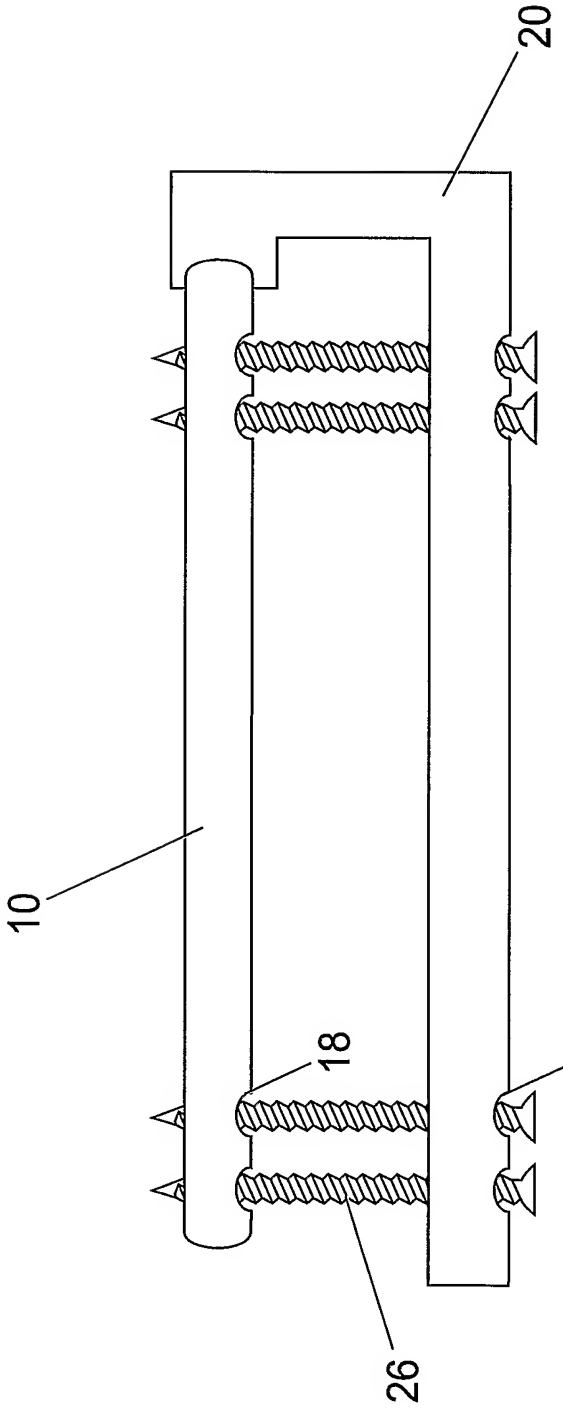

Fig. 2

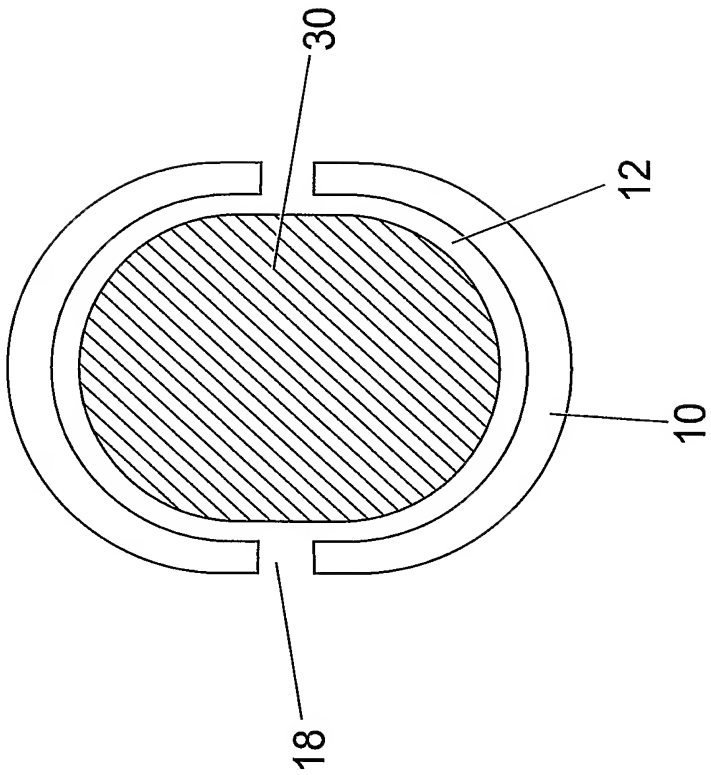

Fig. 3

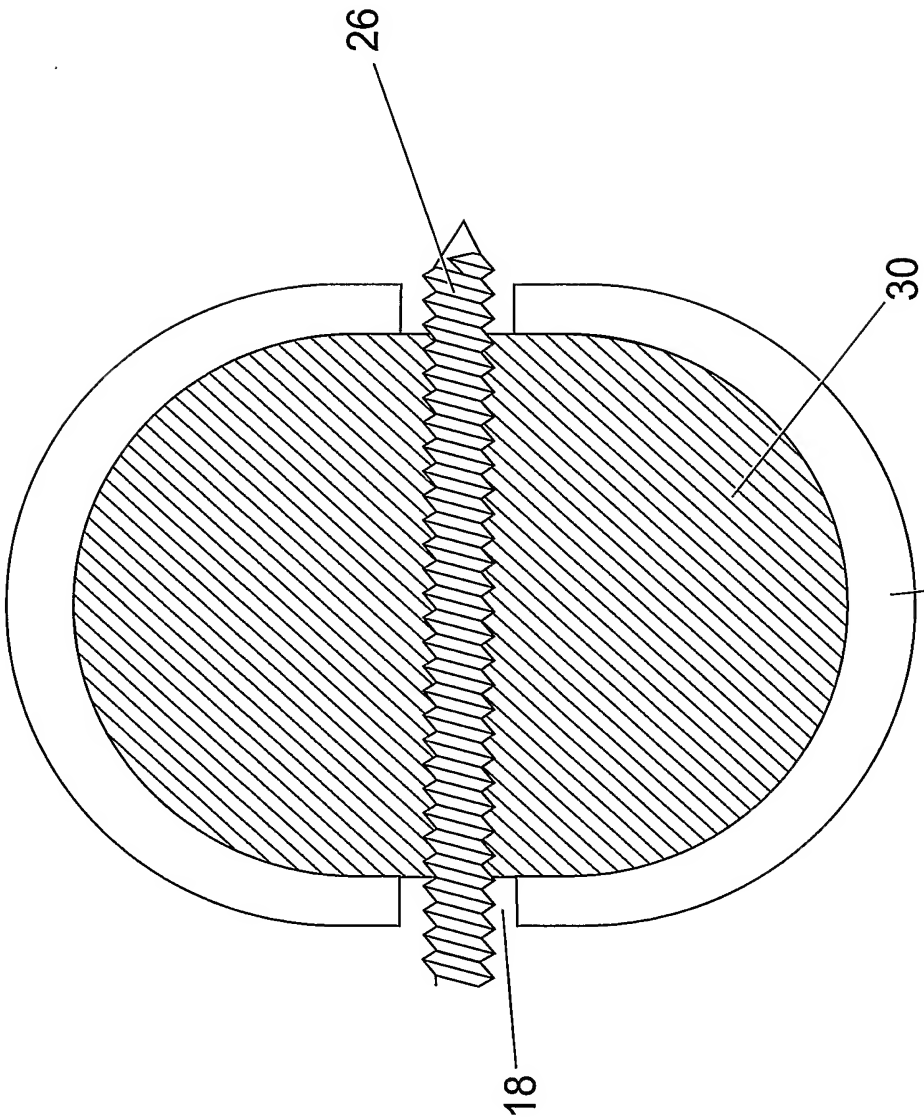

Fig. 4

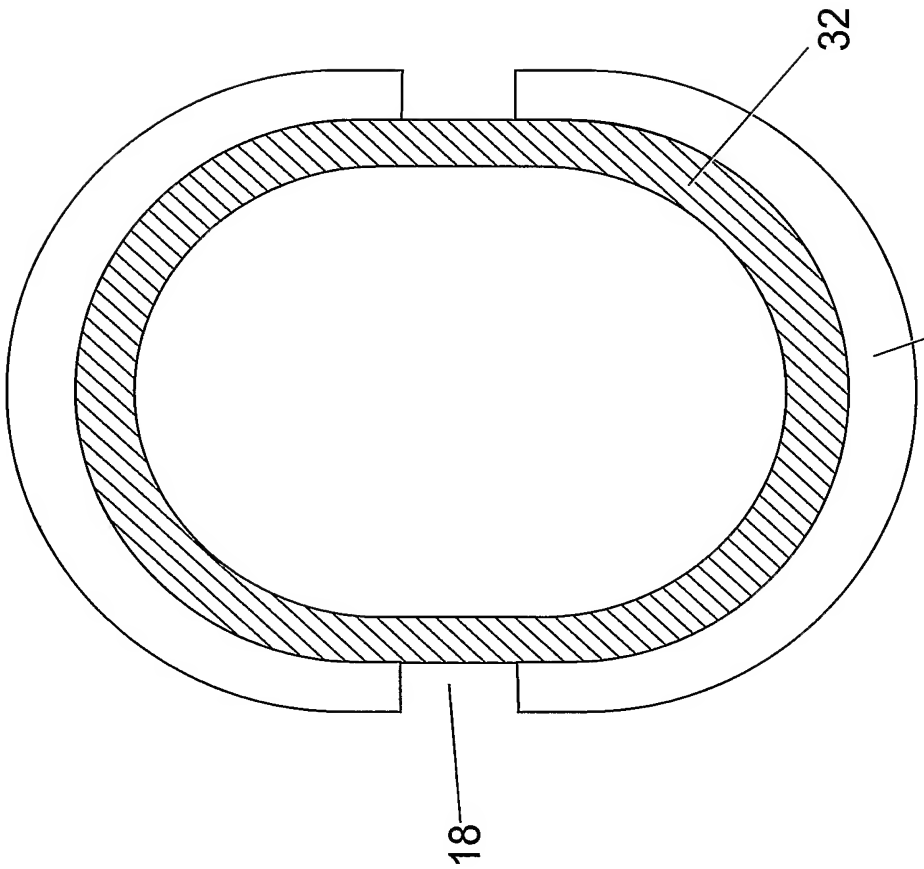

Fig. 5

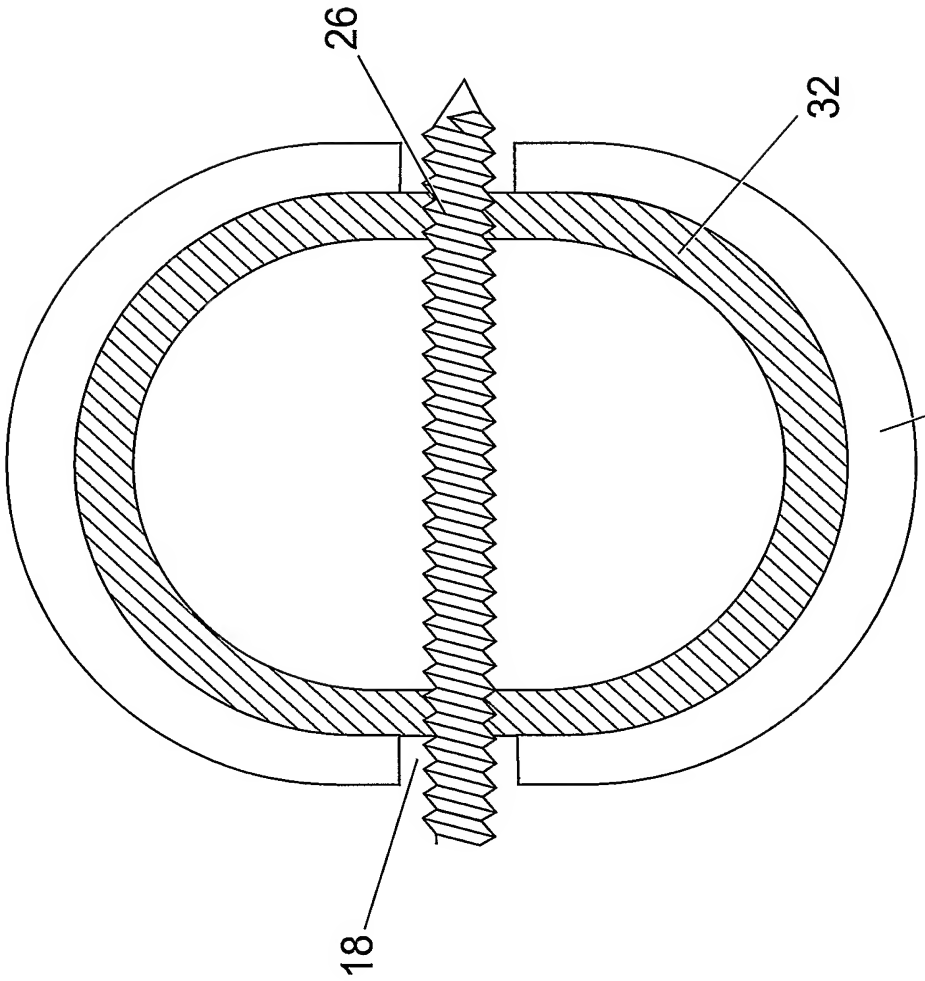

Fig. 6

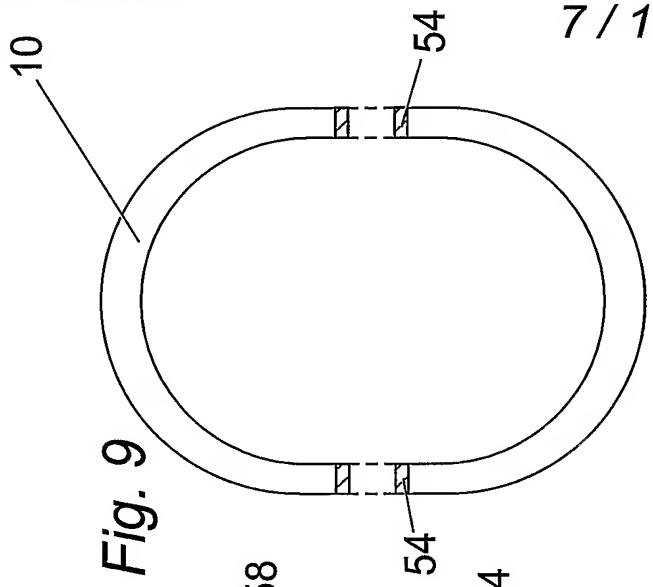

Fig. 9

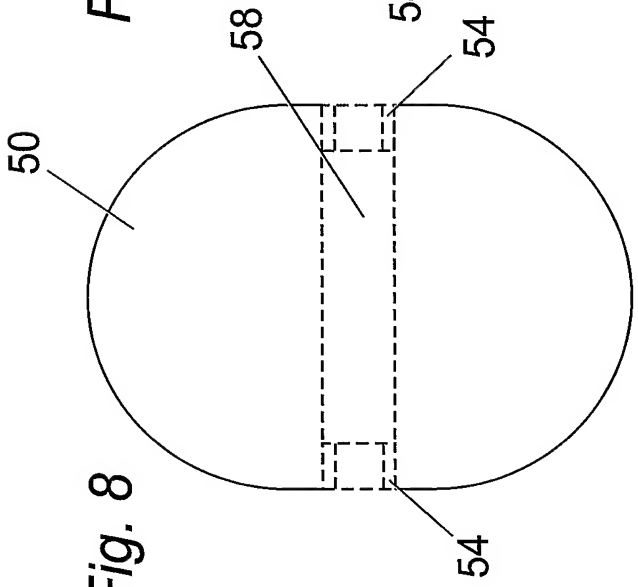

Fig. 8

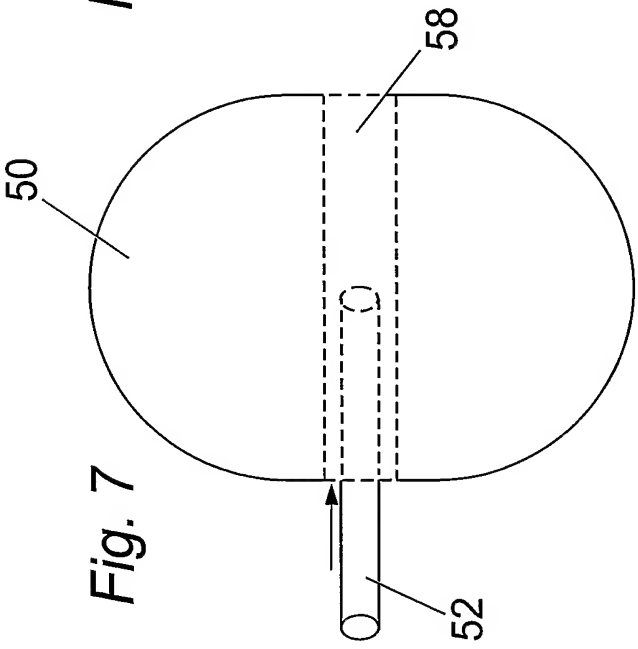

Fig. 7

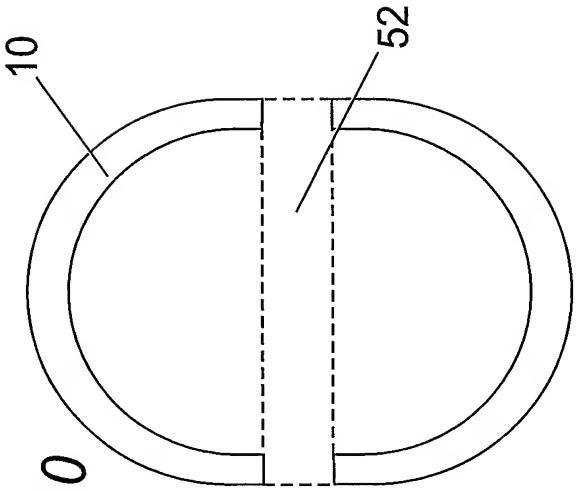

Fig. 10

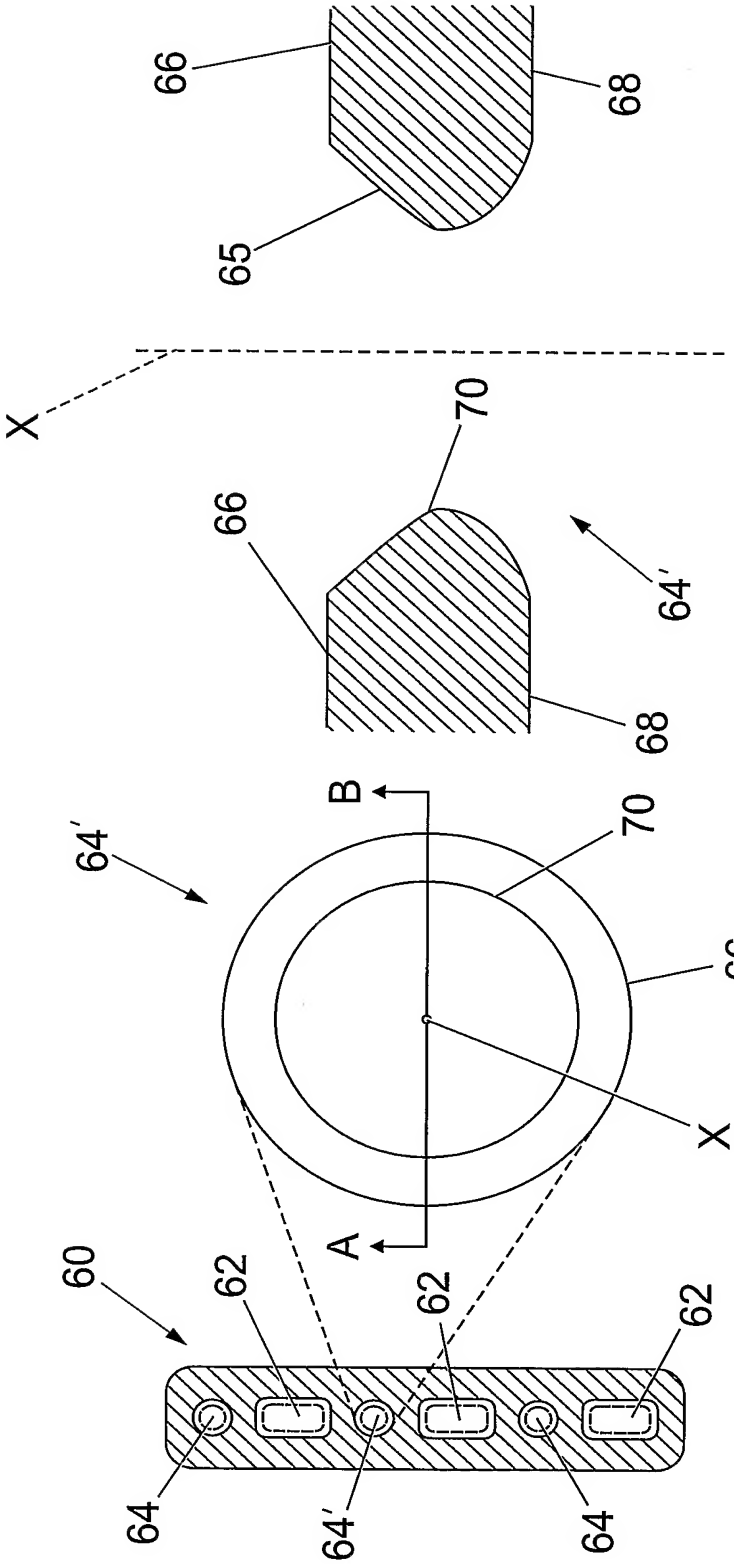

Fig. 13

Fig. 12

Fig. 11

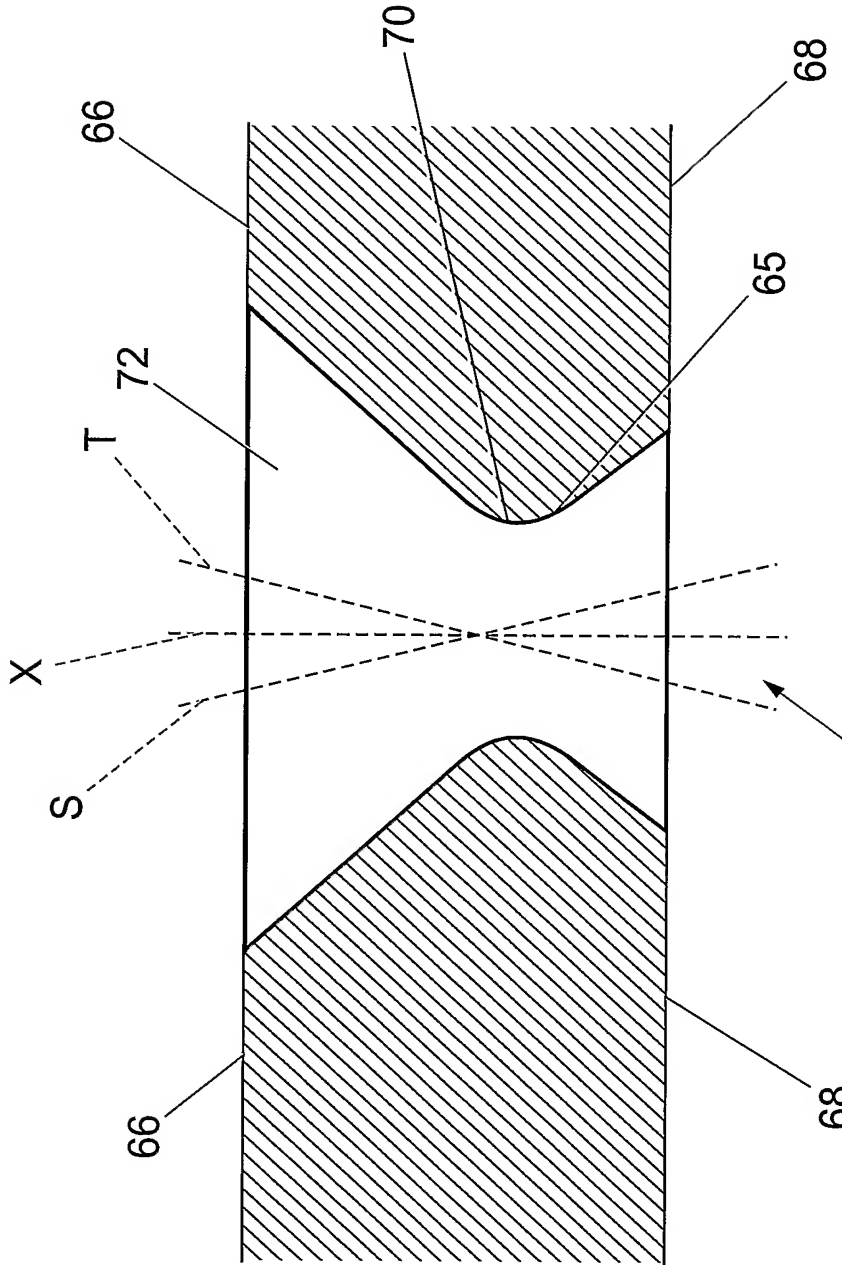

Fig. 14

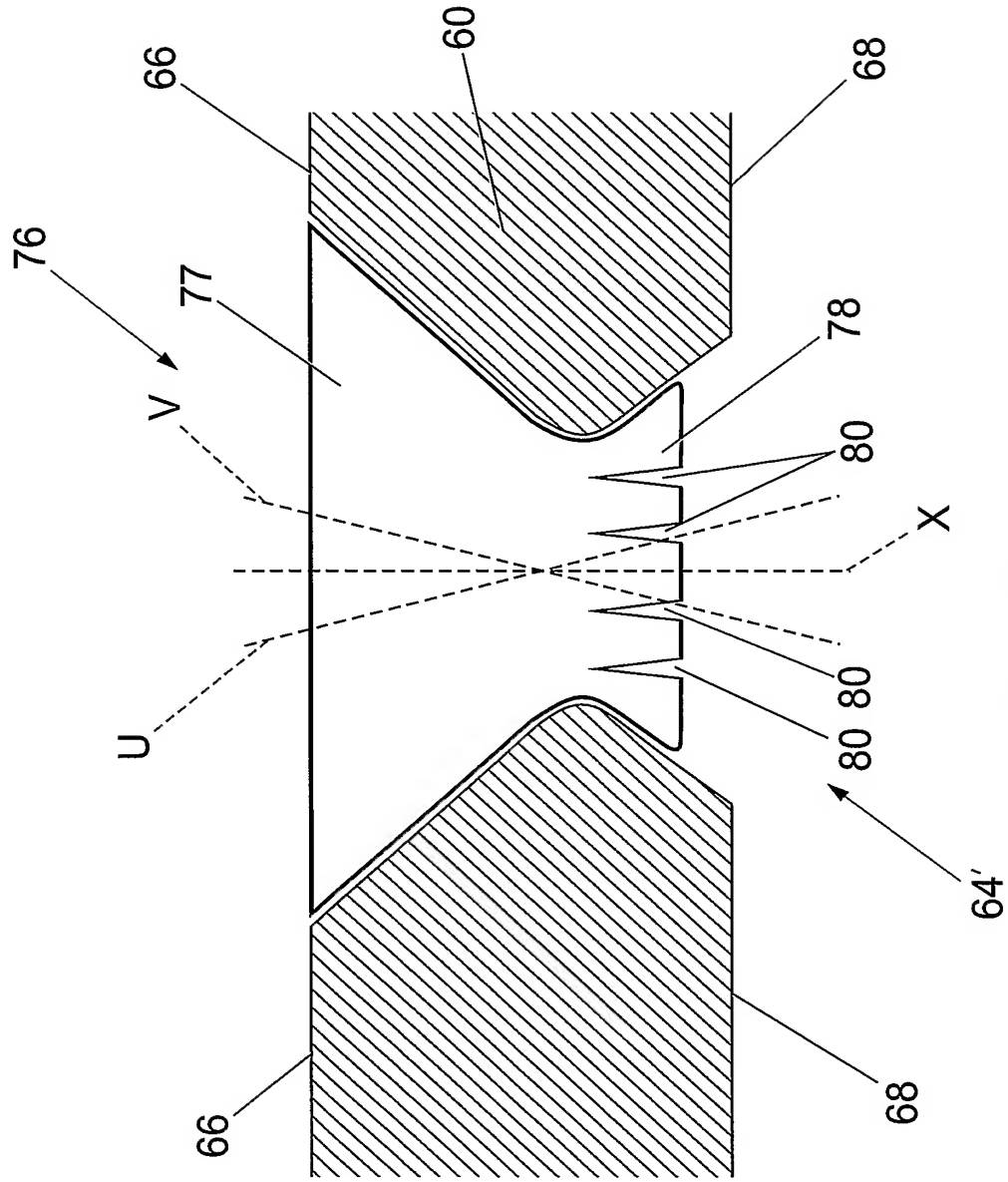

Fig. 15

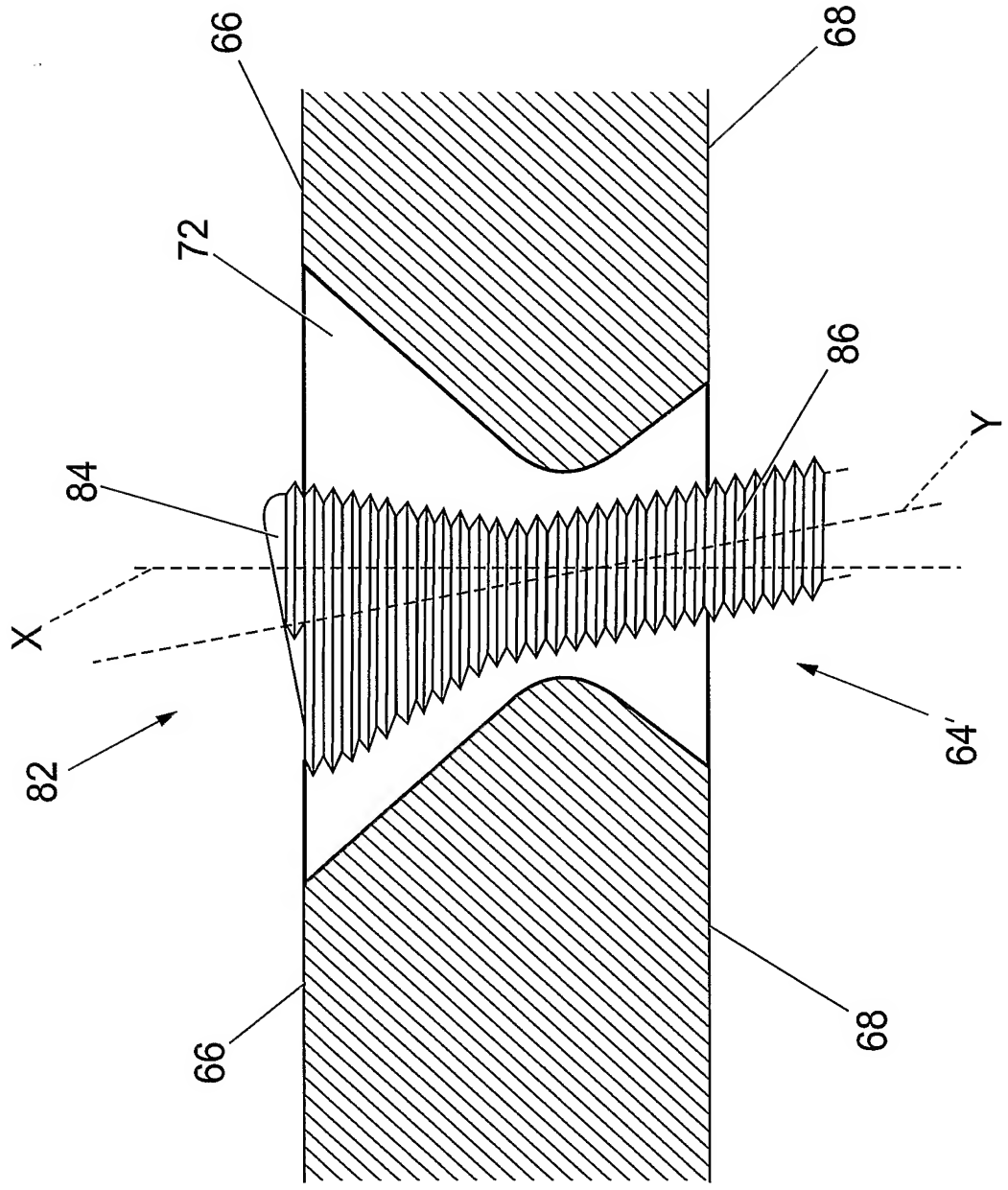

Fig. 16

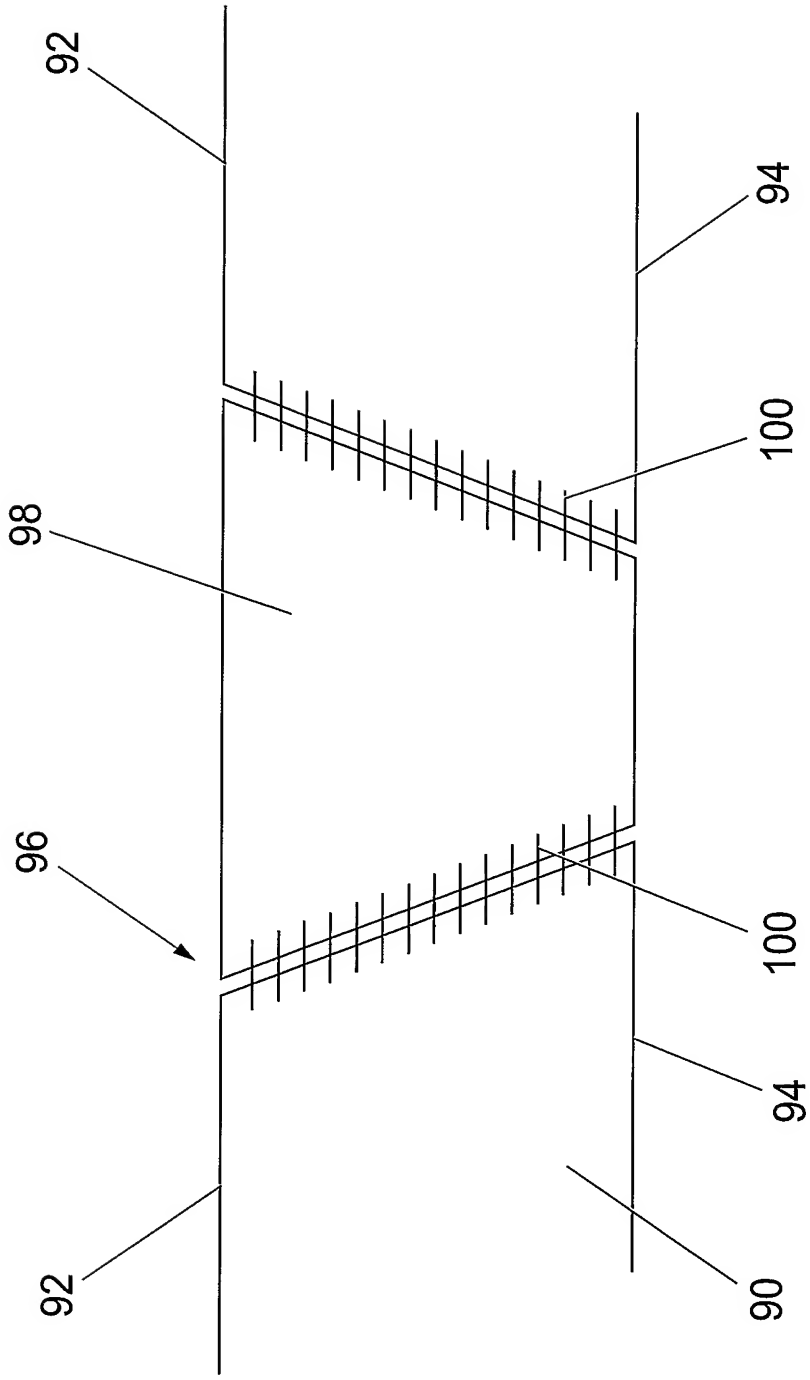

Fig. 17

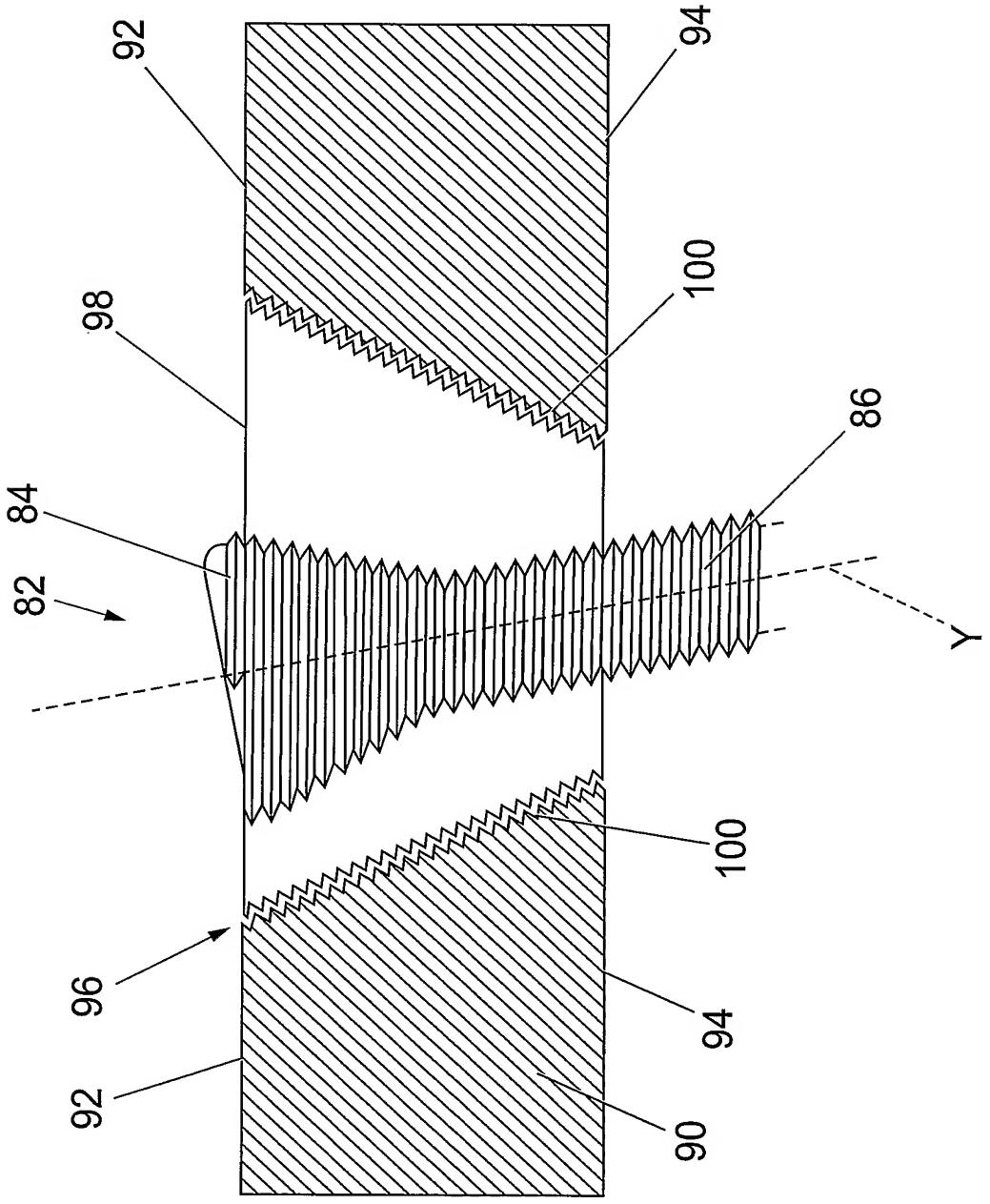

Fig. 18